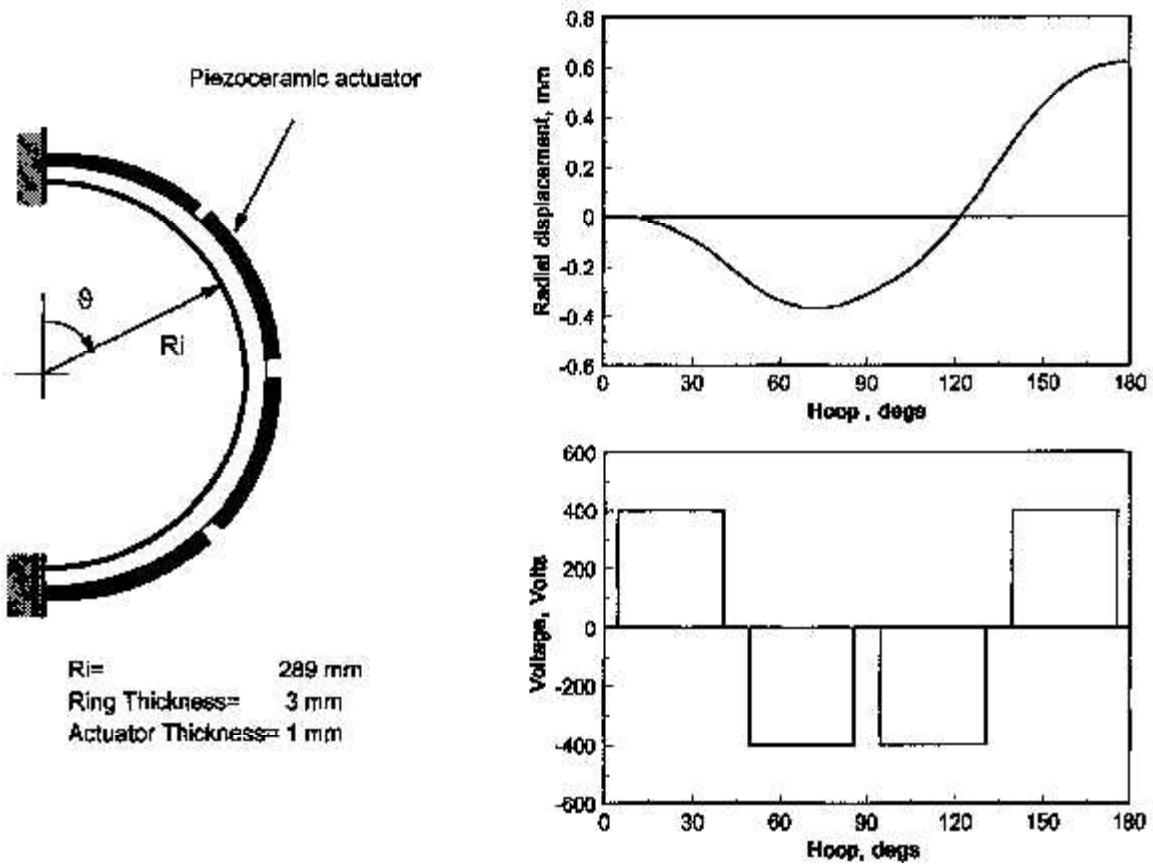
Active Piezoelectric Structures for Tip Clearance Management Assessed

Managing blade tip clearance in turbomachinery stages is critical to developing advanced subsonic propulsion systems. Active casing structures with embedded piezoelectric actuators appear to be a promising solution. They can control static and dynamic tip clearance, compensate for uneven deflections, and accomplish electromechanical coupling at the material level. In addition, they have a compact design. To assess the feasibility of this concept and assist the development of these novel structures, the NASA Lewis Research Center developed in-house computational capabilities for composite structures with piezoelectric actuators and sensors, and subsequently used them to simulate candidate active casing structures.

The simulations indicated the potential of active casings to modify the blade tip clearance enough to improve stage efficiency. They also provided valuable design information, such as preliminary actuator configurations (number and location) and the corresponding voltage patterns required to compensate for uneven casing deformations. The figure illustrates an active ovalization of a casing with four discrete piezoceramic actuators attached on the outer surface. The center figure shows the predicted radial displacements along the hoop direction that are induced when electrostatic voltage (bottom figure) is applied at the piezoceramic actuators. This work, which has demonstrated the capabilities of in-house computational models to analyze and design active casing structures, is expected to contribute toward the development of advanced subsonic engines.



Active ring structures with piezoelectric actuators. Top: Typical configuration. Center: Induced radial deflections. Bottom: Applied electric voltage at actuators.

Bibliography

Heyliger, P.; Ramirez, G.; and Saravanos, D.: Coupled Discrete-Layer Finite Elements for Laminated Piezoelectric Plates. Commun. Numer. Meth. Eng., vol. 10, 1994, pp. 971-981.

Saravanos, D.A., et al.: On Smart Composite Structures for Active Tip Clearance Control. Adaptive Structures and Composite Materials Analysis and Application. E. Garcia, H. Cudney, and A. Dasgupta, eds., ASME, New York, 1994.